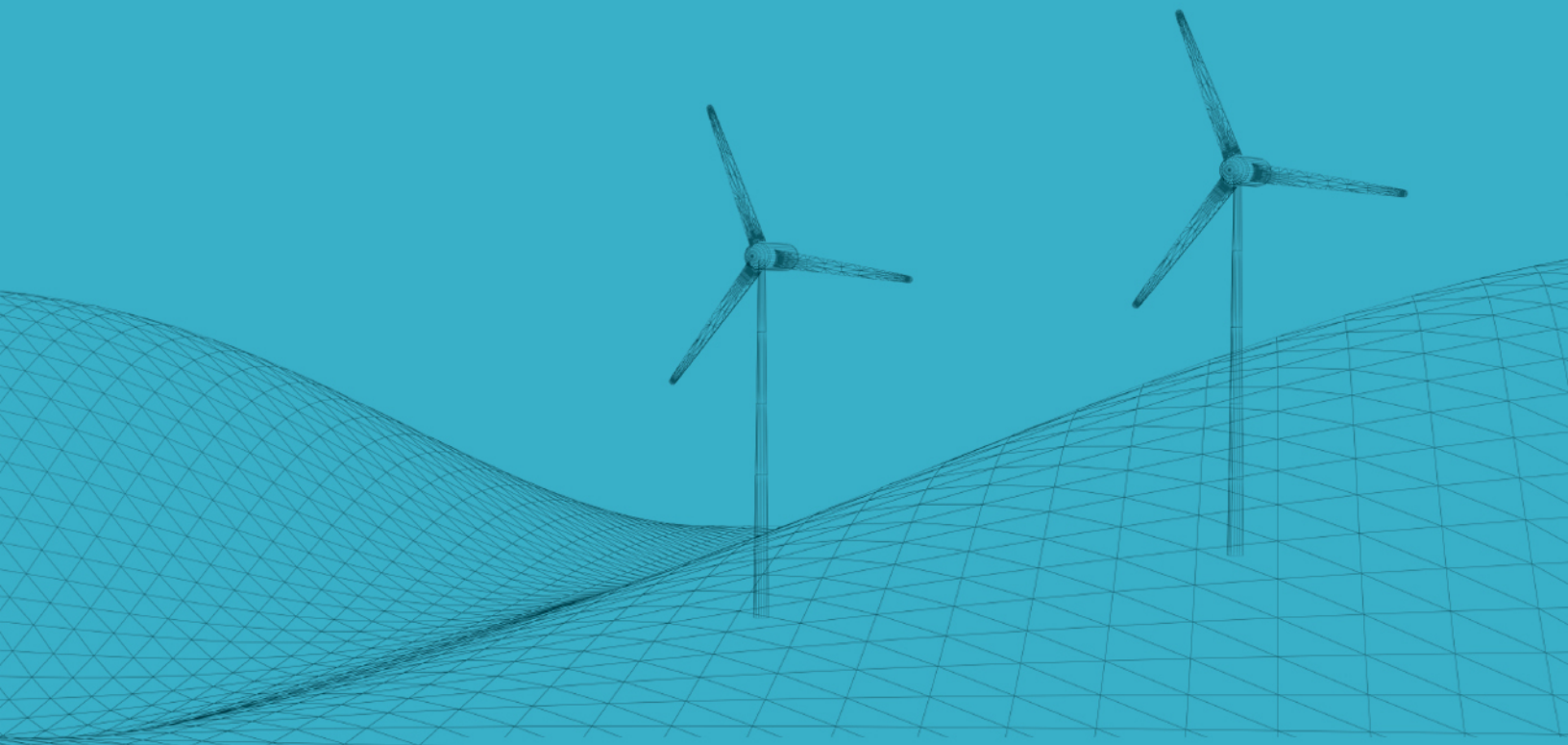
COLLEGIATE
WIND COMPETITION
U.S. DEPARTMENT OF ENERGY



U.S. Department of Energy Collegiate Wind Competition 2016

RULES AND REQUIREMENTS

Revision 3, 2/8/2016

Preface

The U.S. Department of Energy Collegiate Wind Competition 2016 will be governed and adjudicated by this rules and requirements manual, which is intended to establish fair contest rules. The organizers reserve the right to change contest criteria, rules, and measurable outcomes as needed.

In addition, we encourage the teams to bring to our attention rules that are unclear, misguided, or in need of improvement. We will seriously consider suggestions that are feasible and within our constraints and are intended to improve the competition, its rules, measurable outcomes, fairness, or precision.

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Revision History

This document is a revision of the original. Specific changes are detailed below.

- Version 1: Original document issued 8/7/15.
- Version 2: Issued 9/3/15
    - Added detail to better specify the load, point of common coupling and turbine interface in Section 7.1.
- Version 3: Issued 2/08/16.
    - Updated allowable volume turbine must fit within, specifically changing “radius” to “diameter” and providing additional clarification in Section 7.1.

1 Background

The United States installed 66 gigawatts of wind by the beginning of 2015—enough to power 18 million homes. Wind power makes up 4% of the nation's electricity mix, but in states like Iowa and Minnesota, it provides over 20% of their electricity needs. As more wind energy is incorporated into the United States' power generation mix, qualified workers are needed to fill related jobs at all levels.

To help facilitate this process, the U.S. Department of Energy (DOE) and the National Renewable Energy Laboratory (NREL) created the Collegiate Wind Competition in 2014 (hereafter referred to as the Collegiate Wind Competition or competition). The competition directly aligns with DOE's overall goals: to catalyze the timely, material, and efficient transformation of the nation's energy system, secure the United States' leadership in clean energy technologies, and maintain a vibrant domestic effort in science and engineering as a cornerstone of economic prosperity. Specifically, its objective is to prepare students from multiple disciplines to enter the wind energy workforce by providing real-world technology experience. Positions in the workforce that require development include researchers, scientists, engineers, trade workers, educators, transportation workers, business and sales forces, and many others. Wind-energy-specific advanced degrees are not required for many of these jobs, but having wind-related experience is considered to be highly valuable.

2 General

2.1 Overview

The competition challenges interdisciplinary teams of undergraduate students from a variety of academic programs to offer unique solutions to complex wind-energy-related problems. To fulfill the requirements, each team must perform the following multifaceted tasks:

- Develop and deliver a market-research-supported business plan that shapes the design and development of the team's turbine and load into a marketable wind power system.
- Prepare a deployment strategy by identifying a project site for the team's power system and developing a plan based on siting constraints and expected challenges.
- Design, build, and present a unique, wind-driven power system based on market research and test the wind turbine and corresponding load in an on-site wind tunnel.

The Collegiate Wind Competition 2016 focuses on the design and construction of a wind-driven power system that can supply electricity to nongrid-connected device(s). Specifically, competition participants will need to create:

- A mechanical, electrical, and aerodynamic turbine design that is safe, reliable and effective.
- A load system that represents a real-world need, can match the power being generated, and visually indicates the power being generated.

The competition does not prescribe a power system market or wind regime.

2.2 Roles and Responsibilities

Table 1 below shows the competition roles, who is performing in each role, and what it entails.

Table 1. Roles and Responsibilities

Title	Individual Assigned	Definition
Collegiate Team	Multiple	The collegiate teams execute the will of their team members, principal investigator (PI), and co-principal investigators within the rules and requirements of the competition. Teams consist of undergraduate students only but graduate students may be involved as mentors/advisors. There is no limit to team size. Interdisciplinary teams are encouraged in the following areas of study: engineering, business, marketing, communications, policy, and social sciences.
Collegiate Team Leader	One per team	Travels to the kick-off meeting with the PI, represents the team when communicating with competition organizers, and disseminates information received from the competition organizers over the course of the entire project, including monitoring communications (i.e., the Google Group that is discussed later in this manual) during the event.
Collegiate Team Lead Principal Investigator	One per Team	Serves as the lead faculty member and primary representative of a participating school in the project. This person also provides guidance to the team throughout the project and ensures that the team lead disseminates information received from the competition organizers. The PI teaches, advises, and coaches the students on the skills necessary to compete in the various aspects of the competition. Some teams may specify multiple PI's who are primary contacts for the team, but, in this case, one should be identified as the lead.
Collegiate Team Co-Principal Investigator(s) or Supporting Faculty	Multiple	Supports the PI in the above duties but typically do not directly engage with DOE/NREL CWC staff.
Competition Director	Patrick Gilman, (DOE)	Represents the U.S. Department of Energy and has the final decision-making authority in all aspects of the project.
Competition	Amber Passmore, (DOE)	The primary coordinator for the competition.

Manager and Communications Point of Contact		The operations managers, head rules official, and competition organizers report to the competition manager. He/she is the primary point of contact for questions related to engagement with the American Wind Energy Association, keynote speakers, sponsors, and other nonlogistical matters. Duties include, but are not limited to, communicating with all associated participants of the competition and supporting the operations managers and head rules official.
Competition Operations Managers (and Competition Safety Points of Contact)	Elise DeGeorge and Julie Jones, (NREL)	These individuals report to the competition manager and lead correspondence with the collegiate teams regarding contracts, contest questions, and team expectations. They are the primary points of contact for questions related to engagement with the judges. During the competition event, the operations managers are the primary points of contact for logistics questions related to individual competition contests, including wind turbine testing, private business plan and technical design presentations, public pitch presentations, protocol, as well as, and most importantly, safety. Tasks include, but are not limited to, developing teams' schedules and coordinating/collating scores and team feedback from the contests in time for the awards ceremony. Other tasks include supporting the testing team, collegiate teams, judges, competition manager, and head rules official.
Contest Judges	To be announced prior to the competition	Conduct and evaluate each individual contest at the competition.
Rules Panel	See definition	The rules panel members, which will be a subset of the competition organizers and/or contest judges, are the only ones authorized to interpret the rules. If there is any doubt or ambiguity as to the wording or intent of these rules, the decision of the rules panel shall prevail.
Head Rules Official and Turbine Safety Official	Jason Roadman, (NREL)	The head rules official and chair of the Rules Panel. The only official authorized to write and modify the rules. This individual reports to the Competition Manager. The Turbine Safety Official can make the final decision if the turbine cannot be tested in the tunnel due to safety concerns.

Additional Organizers	Mike Arquin, (KidWind) Ian Baring-Gould, (NREL) Lee Jay Fingersh, (NREL) Alex Lemke, (NREL) Suzanne Tegen, (NREL) Kelly Yaker, (NREL)	Perform all duties to ensure a safe and fair competition. The competition organizers, including the competition manager and operations managers, will work to ensure a seamless event.

2.3 Safety and Conduct

The competition is a forum for students with an interest in wind energy to showcase their innovative ideas and demonstrate their knowledge of the wind industry. The event is designed to be safe, fair, and competitive, as well as a fun learning experience and a professional growth opportunity. Each team is responsible for the safety of its operations in accordance with the requirements identified in their contract with NREL (subcontract agreement). Each team member shall work in a safe manner at all times during the competition. Participants are expected to conduct themselves in the spirit of the competition by being team players both within their own teams and amongst competitor teams.

Teams must follow Occupational Safety and Health Administration rules for safety equipment based on expected activities (see NREL/university subcontract, Appendix B Clause 8: Worker Safety and Health Requirements, for more information). Organizers may issue a stop work order at any time during the project if a hazardous condition is identified.

All team members must wear appropriate personal protective equipment when working on, testing, and operating wind turbines. Teams are expected to bring the following appropriate protective equipment for use during wind tunnel testing and other potentially hazardous activities at the competition:

- Safety glasses
- Hard hats
- Steel-toe boots if expecting to handle heavy loads
- Electrical personal protective equipment if electrical voltage demands it
- Hearing protection for use in areas that are in close proximity to the wind tunnel during operation.

Each team is responsible for the transport of its wind turbine and all necessary tools and equipment as well as for any damage to or loss of such items. Shipping information will be provided before the competition event.

There will be standard 110 VAC electrical outlets available in the bull pen area to allow students to operate tools, test equipment, or computers.

As part of DOE's and NREL's culture, renewable energy and sustainability go hand in hand. It is a common public perception as well. As a result, the competition is about renewable wind energy, and we expect that participants will embrace and showcase sustainability where possible during all aspects of the event (e.g., reducing waste in packaging for shipping, re-using packaging materials that were used in transporting items to the competition, and eliminating the use of nonrecyclable materials such as foam packing peanuts). In addition, we encourage team members to engage in common sustainable activities such as recycling paper and beverage containers. Team creativity in this regard is encouraged.

Student participants will be required to sign a Code of Conduct prior to participating in the Event.

2.4 Dispute Resolution

All disputes must be submitted to one of the Competition Operations Managers in writing and include the name and signature of the collegiate team PI, the date of the protest submission, and a clear description of the action being protested. Once submitted, the competition manager will meet with the head rules official to determine whether a dispute is considered minor or major. The head rules official will then make a determination in consultation with competition staff. The head rules official is the only person who can make a final ruling.

Major disputes will be discussed amongst at least three judges and/or competition organizers who will gather appropriate information through interviews or other means, and a final ruling will be issued. If it is concluded that the issue has a broader impact on the entire competition, the head rules official will consult with all necessary members of the DOE/NREL organizing team to determine next steps. Minor rule decisions during the competition event will be made jointly by at least two judges.

After the head rules official makes a decision that may directly or indirectly affect the strategies of some or all of the teams, he will record the decision to the "Decisions on the Rules" section of the Google Group site (discussed further in Appendix C) to document interpretations of the rules contained in this manual.

In all cases, the head rules official has the final say in all disputes and the head rules office.

3 Competition, Contests, Products, and Awards

The Collegiate Wind Competition 2016 consists of all of the aspects and activities leading up to, during, and following the event. It includes the subcontract project agreement between the competitively selected collegiate teams and NREL, as well as the contests, products, and event.

At the event, teams compete in four contests and an unscored bonus challenge. Products receive points toward winning a contest. An overview of which product contributes to the scoring of each of the contests is in Table 2. How many points a product contributes to the overall score is covered in Appendix B. The bonus challenge does not contribute to the overall contest winner's score.

Table 2. Contests and Products Overview

	Products				
Competition Contests	**Written Report**	**Private Presentation**	**Public Pitch**	**Turbine**	**Load System**
Business Plan	✓	✓	✓	-	-
Technical Design	✓	✓	✓	-	-
Deployment Strategy	✓	-	✓	-	-
Turbine Testing	-	-	-	✓	✓
Bonus Challenge	-	-	-	-	✓

This manual is arranged by product. Products include a single written report, one private on-site oral presentation, one public pitch, and the wind turbine for testing. A fifth product is the load system, which is needed for turbine testing as well as participation in the bonus challenge. The bonus challenge does not contribute to the teams' overall score, but provides the teams with an opportunity to be recognized for the creative display of their turbine's capabilities.

While teams work on these products, principal investigators, co-principal investigators, supporting faculty, and members of industry secured by each team for support can provide feedback about the team's design so the students can identify fatal flaws, prove technical rigor, or demonstrate certification of concept.

Awards will be provided for, but not necessarily limited to, the following:

- Overall winner: the team that earns the highest combined score
- Second place winner: the team that earns the second highest combined score
- Third place winner: the team that earns the third highest combined score
- Business plan contest winner: the team that earns the highest combined score from all business plan products

- Technical design contest winner: the team that earns the highest combined score from all technical design products
- Deployment strategy contest winner: the team that earns the highest combined score from all deployment strategy products
- Turbine testing contest winner: the team that earns the highest combined score from all of the turbine tasks
- Bonus challenge winner: the team that earns the highest score on the bonus challenge criteria. Note again that the bonus challenge does not contribute to the overall competition winner's score.

4 Overview of Products and Deadlines

This section gives an overview of when products should be delivered. Refer to each product section and Appendix D for specific deadlines and format requirements. Information on penalties can be found in Appendix B.

4.1 Products in Advance of Competition Event

The written report (See Section 5) and preliminary versions of their public pitch presentation or poster (See Section 6.2) must be completed before the competition. As a result, teams are encouraged to allow time for technical difficulties or unforeseen circumstances and submit early. See Appendix D for more information on submission.

Judges will review the written report ahead of time then refine their review as the products are presented at competition.

4.2 Products at the Competition Event

At the competition venue, judges will:

1. Verify that the wind turbine is accurately represented in the report
2. Ask the team members any clarifying questions that arose during the evaluation of the product(s).

Teams must bring their:

- Private presentation
- Public pitch (presentation) or poster
- Turbine
- Load system.

5 Written Report

Each team must compile a single written report covering the business plan, technical design, and deployment strategy that is due on Sunday, May 1, 2016, by 11:59 p.m. Mountain Daylight Time.

The following format requirements apply to the written report:

- Length must not exceed 40 pages (including the cover and appendices). The paper should be 8.5 x 11 inches, paginated, and with 1-inch margins. Content should be single-spaced, using an 11-point Calibri-type font. Reports not formatted to these requirements will be returned within 24 hours and the late penalties applied (see Appendix B). Any pages beyond the 40 page limit will not be reviewed.

- Captions for figures and tables must be numbered for easy navigation.

- The final document must be packaged into a single, bookmarked PDF file (see Appendix D).

Three contests are included in a single report to encourage integration and cohesiveness throughout the report; each individual section as outlined below should—where relevant—reference other sections. The written report is the primary means for a team to provide detailed information about its project to the judges, given that the judges have a limited opportunity at the competition event to evaluate the wind turbine design specifications and hear about how the market-research-supported business plan shaped the design. Cohesiveness of the report sections will be evaluated in the final score. The report must include the following sections (at a minimum):

- Cover sheet
- Executive summary
- Business plan
- Technical design
- Deployment strategy.

5.1 Cover and Executive Summary

Teams should begin the report with a one-page cover sheet that includes their affiliation and contact information. Indicate the team roles/hierarchy and approximately how many students, faculty, and others (e.g., sponsors, volunteers, and family members) are involved in the project.

The executive summary discusses components from all sections of the report and includes a short description of the team project. The information in the executive summary is important to many communications-related aspects of the competition and should:

- Provide essential content for the organizers to use while developing various event materials (e.g., the website, event program, media kit, and signage)

- Prepare teams to answer questions from visitors at the competition event
- Help organizers and teams respond effectively to media inquiries.

The executive summary must not exceed three pages (including figures). It is recommended to write this section last to best capture the distinct and unique factors of the written report.

5.2 Business Plan

The business plan should be concise and engaging, focusing on all aspects of product development up to the point when the turbine is ready to ship. This approach allows for deployment aspects of the business plan to be emphasized in the deployment section of the written report. However, financial information should include deployment assumptions, with greater detail described in the deployment section of the report.

The business plan must include the following:

- **Business Overview**. This section should include information about the product/company, such as its name, the business model and vision, and a concise overview of the product/company's value proposition (e.g., financial, social, and/or environmental).
- **Market Opportunity**. This section should characterize the overall market opportunity and explain how the product/company will capture a portion of it. At a minimum, a definition of the problem or market gap should be included, along with a market opportunity forecast and potential solutions/competition analyses. This section should also provide a pricing strategy and customer value proposition analysis to support revenue forecasts. It is critical that each team performs substantial market analysis that contains direct outreach. Teams should be prepared to discuss the extent of their market analysis and validation in their presentation to defend their product concept. Some specific questions this section may seek to answer include:
    - What specific market needs does the product offering meet and what segments will you compete in? How does the team's particular turbine meet the needs and desires of the indicated target market? How is the product better than its competition or other solutions for the defined market gap?
    - How will the company price its offering? How does this coincide with the value proposition from the customer's perspective? How does the pricing compare to the competition? How do state, federal, or other incentive programs come into play?
    - How will the proposed venture be capitalized?
- **Management Team**. This section should identify the roles and responsibilities of the company leadership and staff, including strategic advisors or a board of directors (if warranted).
- **Development and Operations**. This section should describe the development of the product, company, and associated activities. Product plans and specifications should be included in an appendix of the written report (full drawings and software not required). Some specific questions this section may seek to answer include:

    - How will research and development be accomplished? What will be the company's approach to manufacturing? How will the product be distributed? What partnerships will be leveraged? What are the significant risks and what is the approach to managing them?
    - Are there technical constraints to implementation? Is the proposed concept buildable? This section is where the wind turbine's technical design, system specifications, energy analysis results and discussion, and engineering narratives can be described. Teams should also include technical, social, and environmental impacts and/or opportunities here.
    - How do the development and operation efforts coincide with the design? Teams should reference sections of their design report (available under the same cover), where appropriate, and plans and specifications should be included in an appendix.

- **Financial Analysis**. This section should outline the financial potential of the product/company noting required capital, financing, and key assumptions (e.g., product marginal costs). Pro forma financial statements—such as the income statement, cash flow statement, and balance sheet—should be presented for the first year, demonstrating the path to solvency and outlining the product/company's potential. It is suggested that full pro formas be included in the Appendix and higher level summaries be used in the business plan narrative, as needed. From an investment perspective, each team should present its view of the valuation of the company at the present time, along with outlining the attractiveness of their company for investment. It is not required or expected that a specific team company be in place, but documentation as if one did exist should be developed.
- **Appendices**. These sections should include full financial analyses, plans, and specifications.

5.3 Technical Design

The technical design section of the written report explains the turbine concept development process from an engineering perspective in response to marketing and performance requirements. Teams are encouraged to detail their entire design process here as they see fit. However, the technical design section of the written report must provide detail that is adequate enough for an engineering review of the baseline and operating properties of the turbine and its subsystems, including loading requirements, operational limits, control algorithms, and software. At a minimum, the following topics should be included:

- A description of the design objective and how the design components support this objective
- A basic static performance analysis (e.g., C_P-Lambda Report) of each team's turbine design that contains the annual energy production over a range of operational parameters
- An analysis of the expected loads and associated safety factors within the design
- An electrical analysis comprised of the generator model, power electronics (e.g., canonical model), load model, and operating voltage

- A control model analysis of the operational modes (i.e., the control states diagram and a description of primary operational modes)
- Documentation of associated software (e.g., control and/or logging) and its development
- Results of laboratory and/or field testing of turbine prototypes
- Engineering diagrams with at least a basic mechanical drawing of all components and an electrical one-line diagram.

5.4 Deployment Strategy

Product deployment, as defined for this competition, consists of all activities that come after the turbine has been manufactured and is ready for transport. Related activities include evaluating project site(s) for technical and environmental suitability, understanding necessary permitting requirements, investigating economic opportunities, and so on. The standard project site and general geographic requirements should correspond to the business plan. Teams should describe the relative wind resource required for unit operation (turbine and load) and describe how this resource overlaps with the target market. In the written report, the deployment strategy must address the following:

- Project site evaluation and selection
- Stakeholder identification and communication
- Deployment timeline and project life cycle
- Installation and maintenance
- Reliability and risk management (specific to deployment).

6 Presentations

6.1 Private Presentation

In addition to the written report, each team will present their business plan and technical design to a panel of judges via a live, oral evaluation. To promote fairness, the evaluation will not be public; however, teams may invite whomever they want into the room, subject to space restrictions. This presentation should convey the most important details of the business plan, technical design, and deployment strategy, clearly communicating the team's intended application and overall approach. It is highly recommended that the team presents in a manner that shows the interdisciplinary nature of the teams.

Presentations are limited to 15 minutes, which will be followed by 15 minutes of questioning from the competition judges only. Presenters should showcase their turbine prototype and may use posters, charts, PowerPoint slides, or other visual aids to engage the audience. A laptop computer will be provided for digital presentations (please bring necessary files on a USB drive).

6.2 Public Pitch

The public pitch challenges teams to convince a panel of experts of the technical underpinnings, business case, and feasibility of deployment of their power system. In 10 minutes, teams should

succinctly make the case that their off-grid power solution is ready for application at the project site, or address issues of why it is not. Details of the deployment strategy, project site evaluation and selection, stakeholder identification and communication, deployment timeline and project life cycle, installation and maintenance, as well as reliability and risk management should be covered briefly. Although the focus is on deployment strategy, the presentation should provide a compelling narration of the inspiration and purpose behind the business plan, illustrating how it has been integrated into the overall strategy and the turbine's technical design, performance, and analysis.

The private presentation, described in Section 6.1, provides the opportunity for the teams to cover the in-depth details of their nondeployment-related business plan and technical design. Yet, the public pitch will not provide enough time to cover those aspects in detail. When pitching an off-grid wind power concept to prospective investors, teams should use this presentation to showcase maximum creativity and salesmanship, highlighting the team strengths and unique approach. Such an approach will naturally involve a professional appearance and manner. Furthermore, each team should be prepared to answer questions for 5 minutes after the pitch from a panel of judges, who will participate as mock project investors. Presenters should highlight their turbine prototype and may use high-quality posters, maps, charts, PowerPoint slides, or other visual aids and props to enhance their presentation. A laptop computer will be provided for digital presentations.

A preliminary version of each team's public pitch presentation or poster is due Sunday, May 1, 2016, by 11:59 p.m. Mountain Daylight Time. Public pitch materials can be modified up to the time of each team's presentation.

The following pitch requirements include:

- A slide show or poster packaged into a single, bookmarked PDF file (see Appendix D)
- A USB drive for teams that are bringing a pitch slide show or poster to their live presentation.

7 Testing

7.1 Turbine Design Requirements

Each turbine prototype must be designed for testing inside the Collegiate Wind Competition wind tunnel, described in detail on the website.

Teams are expected to choose their own generator, design their own load system, and make appropriate selections based on design and application. The load system itself will be designed and built by the teams and must meet safety requirements including, but not limited to, proper wiring practices, shielding of hazardous components, and proper heat rejection. A safety inspection of the wind turbine and load system will be performed by the judges and must be passed before the wind turbine and load system are installed in the wind tunnel. The turbine safety official will make the last and official determination if a turbine may be tested in the wind tunnel. If the team disagrees with this determination a complaint can be filed as per Section 2.4. The design of the load system will be judged as part of a separate, bonus challenge described in Section 8.

For the testing contest:

- The turbine must be designed to withstand continuous winds of up to 18 meters per second (m/s).
- The minimum turbine output must be 10 watts (W) continuous for at least one wind speed from 5 to 11 m/s.
- The team must supply its own load system (Note that this is a significant change from previous contests in which the load was supplied by the organizers).

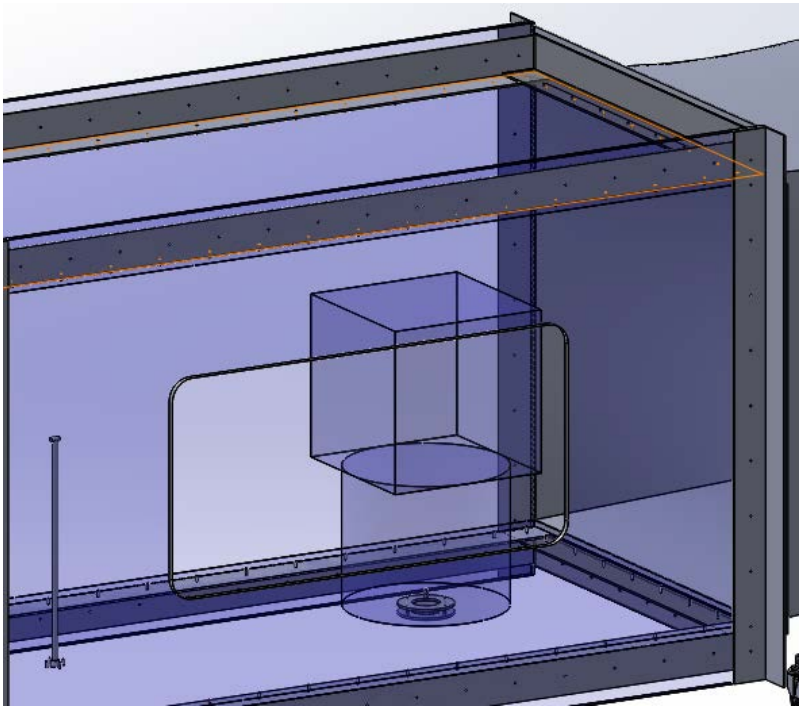

Figure 1. Allowable turbine volume

- For turbine sizing, see Figure 1. The entire turbine must fit within this volume:
    - A 45 cm x 45 cm x 45 cm cube centered horizontally on the flange axis and vertically centered within 2.54 cm of the longitudinal center line of the wind tunnel can contain both rotor and nonrotor turbine parts.
    - A 45-cm diameter cylinder around the vertical center line of the mounting flange extending from the tunnel floor to the bottom of the cube can contain only nonrotor turbine parts. For this purpose, nonrotor turbine parts will be defined as anything that does not capture energy from the moving air.
    - Other electronic components may also be located outside the tunnel. Within practical limits, there is no size restriction for these components.
    - All turbines must fit through the turbine door in one assembly with no additional assembly occurring inside the tunnel other than attachment to the base flange and connection to external electrical components.
    - Refer to the website for tunnel specifications.
- The wind turbine system must be mountable on the test stand at the specified location within the wind tunnel. The turbine base plate must be constructed of material no thicker than a half inch to fit the base flange and to fit over three ¼-inch diameter studs where it will be secured to the base flange with nuts. Refer to the website tunnel specifications for the bolt pattern on this flange. Teams are free to apply their engineering judgment to their own base plate design, keeping in mind that the turbine base must be designed with adequate tolerances such that they can be attached safely to the base flange in the wind tunnel and able to withstand the tension of the mounting studs when torqued to approximately 10 Newton-meters (N-m).

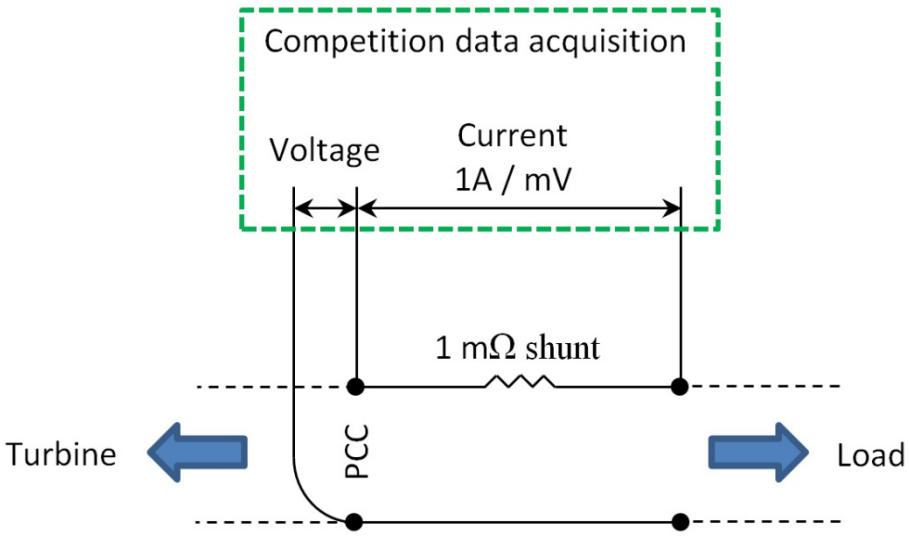

Figure 2. Load, turbine, and point of common coupling arrangement

- Each team must provide a length of wire sufficient to exit the tunnel at the turbine base plus 1 additional meter to the point of common coupling (PCC) on the judge's side of the tunnel

where they will meet the load connectors from the team-provided loading system. This connection will be split and the competition instrumentation will be inserted at this point (Figure 2). A table will be provided to display the load on the opposite side of the tunnel from the judges and the PCC. Teams should provide adequate lengths of wire from the PCC to the load to accommodate their desired load display arrangement on the table.

- Voltage must be DC at the point of common coupling and is required to be below to 48 VDC maximum. Energy storage elements, such as capacitors and/or inductors, may be used in both the turbine and the load but not for bulk energy storage on the turbine side of the point of common coupling.
    - Additionally, for the turbine side of the PCC:
        - No batteries of any type, excessively large capacitors, etc. will be permitted.
        - Teams must show that all components utilized to control the turbine reside on the turbine side of the PCC.
        - Turbine components may draw from the load but must register a zero state of charge at the beginning of the test.
        - Verification of zero energy at the start of the test will be accomplished by the use of the competition data acquisition system to measure zero voltage and current flow at the point of common coupling. Any questionable electrical elements are subject to additional verification of zero energy by the testing team through the use of a multi-meter before the testing begins.
    - For the load side of the PCC:
        - Bulk energy storage is allowed provided it is utilized in a safe and reliable manner.
        - 120 VAC will be provided to run the load if desired.
- To interface with the PCC, wires should be terminated with Anderson Powerpole connectors, PP15-45 (a red and a black for positive and negative). Teams are expected to provide their own Powerpole connectors of appropriate size: 15A, 30A, or 45A, which are specified to handle wire gauges from 10 American wire gauge (AWG) through 20 AWG. Each team can choose the wire size it wants to use in this range as long as the appropriate current carrying capacities are taken into consideration. All three pin sizes fit into the same housing (PP15-45) as stated above.
- Turbines must be capable of shutting down on command as well as when electrically disconnected. During the contest:
    - The judges will initiate an electrical shutdown by disconnecting the turbine connection to the point of common coupling.
    - Manual shutdown will be triggered by a competition-provided, normally closed switch that is typical of normal industrial emergency stop circuits and will be located outside the tunnel. Judges will initiate a manual shutdown by depressing the switch and opening the circuit. To connect to this circuit:

- Each team must provide two wires (22–28 AWG) that are at least 2 meters in length exiting the tunnel at the base flange to reach this switch. These wires should be terminated, prior to the competition, with a standard JST RCY female receptacle housing (Manuf. P/N: SYR-02T housing using SYM-001T-P0.6(N) for the corresponding male pin contacts).[1]
- The competition switch will be terminated with the corresponding polarity JST RCY male plug (Manuf. P/N: SYP-02T-1 plug housing using SYF-001T-P0.6(LF)(SN) socket contacts).[1]

7.2 Turbine Testing Contest

The turbine testing contest consists of a number of individual turbine tasks. This section describes the requirements of the individual tasks in which the turbine is expected to perform and the parameters of the testing conditions. Details on scoring algorithms and point allocations between individual tasks can be found in Appendix B.

Testing provides teams with the opportunity to demonstrate their turbine's performance through objective tasks—and the testing outcomes help determine if they have succeeded in developing a durable, safe, high-performing machine (performance is a strong indicator of a turbine's ability to compete successfully in the marketplace).

Each turbine, along with its corresponding load system, will be tested in the competition wind tunnel and include the following tasks: turbine performance, turbine rated rpm and power control, cut-in wind speed, turbine durability over a range of wind speeds, and turbine safety.

7.2.1 Testing Procedure

All teams will follow the same prescribed schedule for testing in the wind tunnel. Only one team's turbine will be tested at a time. Each team will have 30 minutes of tunnel time, 25 minutes to install the turbine and complete all testing, and 5 minutes to remove the turbine. If there are unforeseen delays caused by the organizers (e.g., a wind tunnel issue or power outage), the time spent rectifying the problem will not be included as part of the team's allowable minutes. Team members will not be allowed to touch their turbines or controls during the test. Turbine failure is defined as anything out of the ordinary such as cracking, breaking, pieces falling off, smoking, sparking, or failure to produce an electrical current.

If a team cannot complete its testing during the allocated 30-minute period, the members may request a single re-test for a subsequent 30-minute period later during the competition. The re-test will be a full test, and all scores from the first test will be replaced. Re-testing will be conducted on a first-come, first-served basis. Teams will have an opportunity to sign up on the

[1] Note: in the remote control aircraft community, these connector pairs are commonly referred to as "JST BEC" connectors and are available from a variety of sources, including Digi-Key.

re-test request list that will be maintained at the tunnel by the tunnel operator throughout the competition during or following their initial test but not before.

Students are encouraged to bring spare components and/or assemblies and to design the turbine so that damaged parts or assemblies can be easily replaced; however, it is important to keep the following in mind:

- Once testing starts, the team supplied load system will provide the basis for the testing score as well as be the load that is scored for the bonus challenge. Spare loads are allowed, but the load used for the testing score will be the same one used for the bonus challenge.
- The turbine configuration throughout the entire competition must remain substantially the same as what is documented in the written report. For example, the number of blades, rotor axis, turbine configuration, operating voltage, and so on must remain the same. Teams with questions about any changes or altered turbine components or assemblies are encouraged to discuss their particular situation with the organizers well ahead of the competition to ensure that they are adhering to this requirement.

7.2.2 Power Curve Performance Task

The objective of this task is to test each turbine over a range of wind speeds to determine a power curve. It is meant to be a direct comparison of power performance between turbines, which is one factor by which real turbines are judged.

Each turbine will be tested at integer wind speeds between 5 and 11 m/s inclusive for a maximum duration of 60 seconds (s) or less, with the stated intent of obtaining a "stable power reading" defined as "stable in rpm and stable in power per multimeter readings" during the test period. As power output may fluctuate, for purposes of this task, the allowable power outputs to be included in the maximum average power (per electronic testing devices) during any 5-s interval will be defined to be +/-10% of the maximum average power.

7.2.3 Control of Rated Power and Rotor Speed Task

Wind turbines have to withstand high winds without damage to their mechanical or electrical components. Because wind power is proportional to the cube of wind speed, the energy available in the wind quickly becomes very high as the wind speed increases. To control rising mechanical and electrical loads, turbines must be able to limit their rotational speed and output power in these high wind conditions.

In this task, each turbine will be subjected to wind speeds of 12 m/s and 13 m/s and compared to a rated wind speed of 11 m/s. The turbines are expected to keep the rpm at or below the rpm determined at 11 m/s and to keep the power at the same level as was determined at 11 m/s.

7.2.4 Cut-In Wind Speed Task

Cut-in wind speed—the speed at which a turbine produces power—is one of the characteristics that can differentiate one turbine as being better suited to lower wind-speed regimes than others. Lower wind speed is generally deemed more desirable in the small turbine market.

In this task, each turbine will be subjected to slowly increasing wind speeds up to 5 m/s to determine the cut-in wind speed. For this task, "producing power" is defined as achieving a positive current (A) average over a 5-s interval at a steady wind speed.

7.2.5 Durability Task

Turbines are expected to perform over the long term and will be subjected to a wide variety of weather conditions. Being able to produce power effectively and over the course of the turbine's lifetime are desirable design qualities.

In this task, each turbine will be subjected to the same prescribed variable wind speed function that is never less than 6 m/s nor greater than the maximum continuous wind speed specified in the turbine requirements section (Section 7.1) over a 5-minute test period. This test helps verify that the turbine can function under a wide range of operating conditions.

7.2.6 Safety Task

Safety is of utmost importance to turbine designers and manufacturers. To be certified, turbines must be able to safely shut down rapidly and with a fail-safe, back-up shutdown capability. Turbines must shut down when disconnected from the grid as well as manually upon command as described in Section 7.1. Each team may choose to address these shutdown scenarios with one or two systems or mechanisms.

In this task, the turbine will be required to safely shut down at two different times during the testing period at any wind speed—up to the maximum continuous wind speed specified in Section 7.1. For each individual turbine, the shutdown process will be initiated once "on command" and separately by electrical disconnect. The turbine must be capable of re-starting between tasks at any wind speed above 5 m/s. For the purposes of this task, "shutdown" is defined as dropping below 10% of the rated turbine rotor rotational speed as specified by the team, or the maximum rpm achieved during the prior testing, whichever is greater. This reduction in rpm must occur within 10 s.

8 Turbine Load and Bonus Challenge

Each team must provide a load system for turbine testing. This system provides a testing environment that is tailored to the intended application of the individual turbine and accommodates a wide range of generators. The loading system should characterize the intended application for the turbine as expressed in the business plan. There will also be a bonus challenge that focuses on the display of the loading system. The winning load system will offer the most creative, functional, informative, and elegant representation and display of the power being generated by the turbine in the wind tunnel, while also properly acting as the load on the turbine.

The bonus challenge scoring has no impact on each team's overall competition score. However, the load must function for teams to receive a score during tunnel testing. It must, at a bare minimum, provide an adequate, safe electrical load so that the turbine can produce the necessary power for all testing objectives. Once the wind tunnel test begins, the load that is connected will be scored for the bonus challenge and provide the basis for the turbine testing score. Backup loads are allowed and encouraged, but the load used for the wind tunnel testing score is the one that is scored for the bonus challenge. As part of the bonus challenge, but not necessary for turbine testing, the energy measurement and display must be capable of being reset at the start of testing.

The competition technical judging team, led by the head rules official, will evaluate and score the loading systems to determine a bonus challenge winner in accordance with Table B-7 in Appendix B.

For the purpose of scoring the bonus challenge, each team should prepare a video or other presentation of their load in operation. Prior to the wind tunnel test, judges will inspect the load for safety and view the presentation to help when scoring the load. Teams are encouraged to have the presentation and load on display in their bullpen area. There will be electrical outlets available in this area to power the load for demonstration purposes and for the presentation. Additional consideration will be provided for a load that closely resembles the specific market need being met by the turbine design. In addition to the bonus challenge winner, there will be a people's choice award for the best load design (voted on by all present at the event).

Glossary

Competition	The competition is all aspects and activities leading up to, through, and following the event. It is the subcontract project agreement between the competitively selected collegiate teams and NREL, the contests, products, and event, collectively referred to as the U.S. Department of Energy Collegiate Wind Competition 2016.
Contests	The competition consists of four contests with multiple products.
Products	Products are what the team builds, writes, submits, and brings to compete in the competition.
Event	The event is when and where the teams compete in the contests.
Test	The overall time period in the wind tunnel during which each team's turbine is subject to various wind speeds and scored on the testing tasks.
Task	Each individual achievement goal of the test turbine that will be scored during the wind tunnel testing period.

Appendix A. Timeline and Schedule

Competition Timeline

The competition timeline shown in Table A-1 assumes a biannual event.

Table A-1. This Year's Competition Timeline and Related Activities

Month/Year	Competition Activity
Fall 2014	Release of competition requests for proposals
Spring 2015	Proposals due/Announce competition teams/Negotiate contracts
August 2015	Kick-off meeting for competition
Fall 2015	Concept development
Spring 2016	Product development and testing
May 2016	Competition takes place
June 2016	The winning wind turbine is put on display at the U.S. Department of Energy headquarters in Washington D.C. A review meeting/conference call is held to review the competition and make recommendations for the next event.

Event Schedule

Day 1 (Monday)

8 a.m.–8:30 a.m.	Lottery sign up and tunnel safety session
8:30 a.m.–4 p.m.	Turbine/load safety inspections and wind tunnel practice
4 p.m.–5 p.m.	Rules and logistics meeting with teams and principle investigators
5 p.m.–6 p.m.	Welcome reception

Day 2 (Tuesday)

8 a.m.– 8:20 a.m.	Day one overview
8:30 a.m.–3:00 p.m.	Turbine performance testing
9:30 a.m.–3:50 p.m.	Engineering design/ business plan judging
3:00 p.m.–6 p.m.	As needed: turbine testing make-up

Day 3 (Wednesday)

8:30 a.m.–8:50 a.m.	Day two overview
9 a.m.–12 p.m.	Project pitches
9:30 a.m.–12 p.m.	Engineering design/ business plan judging
12 p.m.–1 p.m.	Lunch
1 p.m.–2:15 p.m.	Project pitches
1 p.m.–2:10 p.m.	Engineering report/ business plan judging
2:15 p.m.–5 p.m.	Judges/organizers confer
5 p.m.–5:30 p.m.	Reception
5:30 p.m.–6:30 p.m.	Awards ceremony

Turbine performance testing activities
Engineering report/business plan (Private)
General activities with all participants
Project Pitches (Public)
Organizers-only activities

Figure A-1. Competition event schedule

The competition event is expected to be held in accordance with the schedule provided in Figure A-1; however, times are subject to change anytime up to the event. The final, more detailed schedule will be provided to the teams before and at the competition, including a team-specific customized schedule highlighting where each team needs to be and when throughout the event.

Appendix B. Rubrics

Products

Table B-1. Scoring Summary for the Competition Products (1,000 Points Total)

Competition Contests	Total Scores	Products				
		Written Report (300)	Private Presentation (200)	Public Pitch (200)	Turbine (300)	Load System
Business Plan	250	125	100	25	-	
Technical Design	250	125	100	25	-	
Deployment Strategy	200	50	-	150	-	
Turbine Testing	300	-	-	-	300	Required
Bonus Challenge	Bonus					Separate from overall score

Written Report

Table B-2. Scoring Rubric for the Written Report (300 Points Total)*, **

Description	Possible Points	Score
Business Plan (125 points)		
Market deployment feasibility (marketability, buildability, public/market acceptance)	25	
Risk recognition and management	25	
Innovation, creativity, and originality	25	
Presentation (i.e., how well the plan is presented in writing)	15	
Financial analysis and documentation	25	
Cohesiveness with the technical design, deployment strategy, and executive summary	10	
	Subtotal	

Description	Possible Points	Score
Technical Design (125 points)		
Design objective description	10	
Static performance analysis	15	
Load system analysis and associated safety factors	15	
Electrical analysis	15	
Controls analysis	15	
Software documentation and description	10	
Results from laboratory and/or field testing	20	
Engineering diagrams including mechanical and electrical drawings	15	
Cohesiveness with the business plan, deployment strategy, and executive summary	10	
	Subtotal	

Description	Possible Points	Score
Deployment Strategy (50 points)		
Project site(s) evaluation and selection	8	
Stakeholder identification and communication	8	
Deployment timeline and project life cycle identification	8	
Installation and maintenance strategy	8	
Reliability and risk management (specific to deployment)	8	
Cohesiveness with the business plan, technical design, and executive summary	10	
	Subtotal	
	Total	

*** 5% of total allowable points, distributed evenly across each contest section, will be deducted for each day the report is late.**

****Reports that do not meet formatting requirements will be returned to the team within 24 hours of submission for correction. The penalty for late submission will apply as a result.**

Private Presentation

Table B-3. Scoring Rubric for the Private Presentation (200 Points Total)

Description	Possible Points	Score
Business Plan (100 points)		
Market deployment feasibility	15	
Risk reduction and management	15	
Innovation, creativity, and originality	15	
Financial analysis	25	
Practiced and compelling presentation style and professional appearance and manner	10	
Utilization of effective graphics, media, and/or props	10	
Illustrates integration with the technical design and deployment strategy	10	
	Subtotal	

Description	Possible Points	Score
Technical Design (100 points)		
Design objective description	15	
Static performance analysis	10	
Load system analysis and associated safety factors	10	
Electrical analysis	10	
Controls analysis	10	
Software documentation and description	10	
Results from laboratory and/or field testing	15	
Engineering diagrams including mechanical and electrical drawings	10	
Illustrates integration with the business plan and deployment strategy	10	
	Subtotal	
	Total	

Public Pitch

Table B-4. Scoring Rubric for the Public Pitch (200 Points Total)*, **

Description	Possible Points	Score
Business Plan (25 points)		
Compelling narrative of inspiration and purpose behind the business plan	15	
Illustrates integration with the technical design and deployment strategy	10	
	Subtotal	

Description	Possible Points	Score
Technical Design (25 points)		
Compelling summary of design, performance, and analysis for a wide audience	15	
Illustrates integration with the business plan and deployment strategy	10	
	Subtotal	

Description	Possible Points	Score
Deployment Strategy (150 points)		
Compelling description of deployment strategy details	20	
Practiced and polished presentation style, professional appearance, and manner	20	
High-quality graphics, media, and props to support presentation and aid visualization	20	
Project site(s) evaluation and selection	15	
Stakeholder identification and communication	15	
Deployment timeline and project life cycle	15	
Installation and maintenance	15	
Reliability and risk management	15	
Illustrates integration with the business plan and technical design	15	
	Subtotal	
	Total	

*** 5% of total allowable points, distributed evenly across each contest section, will be deducted for each day the presentation is late.**

****Slides that do not meet formatting requirements will be returned to the team within 24 hours of submission for correction. The penalty for late submission will apply as a result.**

Turbine Performance Testing

Table B-5. Scoring Rubric for Turbine Performance Testing (300 points total)

Description	Possible Points	Score
Turbine Performance Testing (300 points)		
Power curve performance task	100	
Control of rated power	25	
Control of rated speed	25	
Cut-in wind speed task	50	
Durability task	50	
Safety task	50	
	Subtotal	
	Total	

Scoring algorithms for each testing task are described below.

Power Curve Performance Task

If the turbine does not meet the minimum continuous power output specified in the turbine design requirements for at least one wind speed from 5 to 11 m/s, the score for the power performance task will be zero. A total score for this task will be calculated according to Table B-6 by multiplying each power measurement in watts in the 1-m/s wind speed intervals from 5 m/s to 11 m/s by the factor given.

Table B-6. Weighting for the Power Curve Performance Task

Wind Speed (m/s)	Factor
5	1.3
6	1.5
7	1.5
8	1.3
9	0.9
10	0.5
11	0.3

Note: If a particular test point cannot be reached by the wind tunnel for any competitor, all teams will receive full points for that test point.

Control of Rated Power and Rotor Speed Task

Scores for power will be calculated according to the following formula.

Ratio = measured power in each bin/measured power at 11 m/s
Score for each bin = 12.5 * ((tanh(-20*abs(ratio-1)+pi)/2+0.5)/(tanh(pi)/2+0.5))

In Figure B-1, a ratio of 1.000 represents perfect power control at exactly the same value as was measured in the 11-m/s bin. The weighting shown will be multiplied by 12.5 for the 12-m/s and 13-m/s bins to obtain scores for each bin.

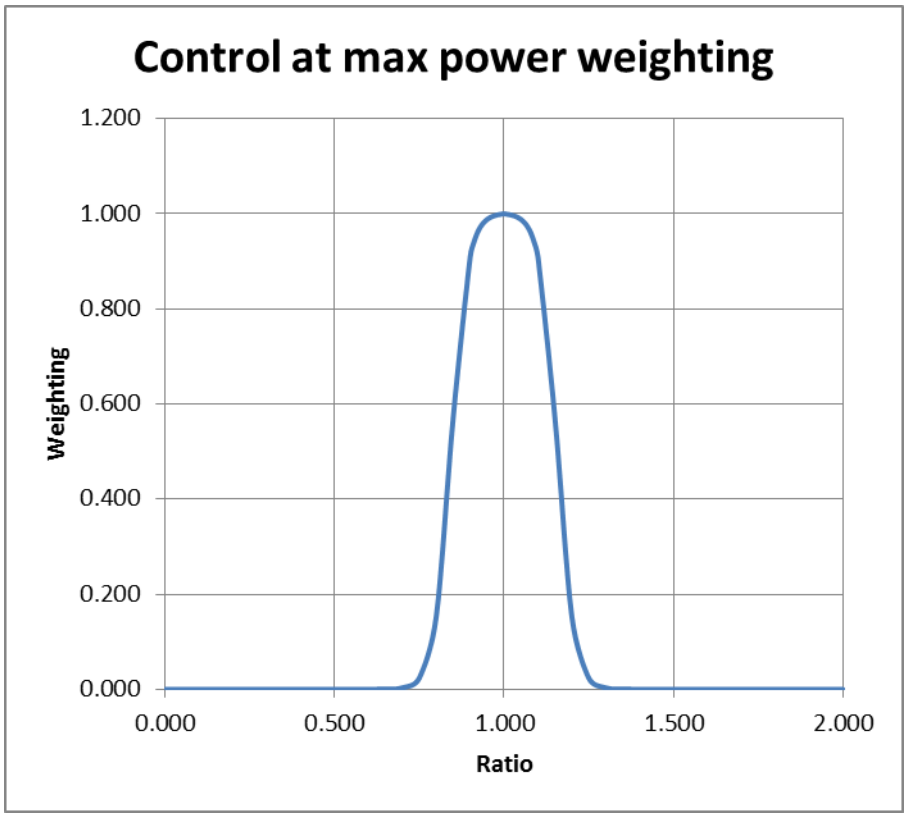

Figure B-1. Score weighting based on power ratio for control of rated power task

Scores for rotor speed control will be calculated according to the following formula.

Ratio = measured speed in each bin/measured speed at 11 m/s
0 < ratio < 1.03: score for each bin = 12.5
ratio >= 1.03: score for each bin = 12.5 * ((tanh(-20*abs(ratio-1.03)+pi)/2+0.5)/(tanh(pi)/2+0.5))

In Figure B-2, a ratio of 1.000 represents the perfect rotor speed control at exactly the same value as was measured in the 11-m/s bin. The weighting shown includes a 3% buffer above and infinite buffer below that speed to obtain full points. The weighting shown will be multiplied by 12.5 for the 12-m/s and 13-m/s bins to obtain scores for each bin.

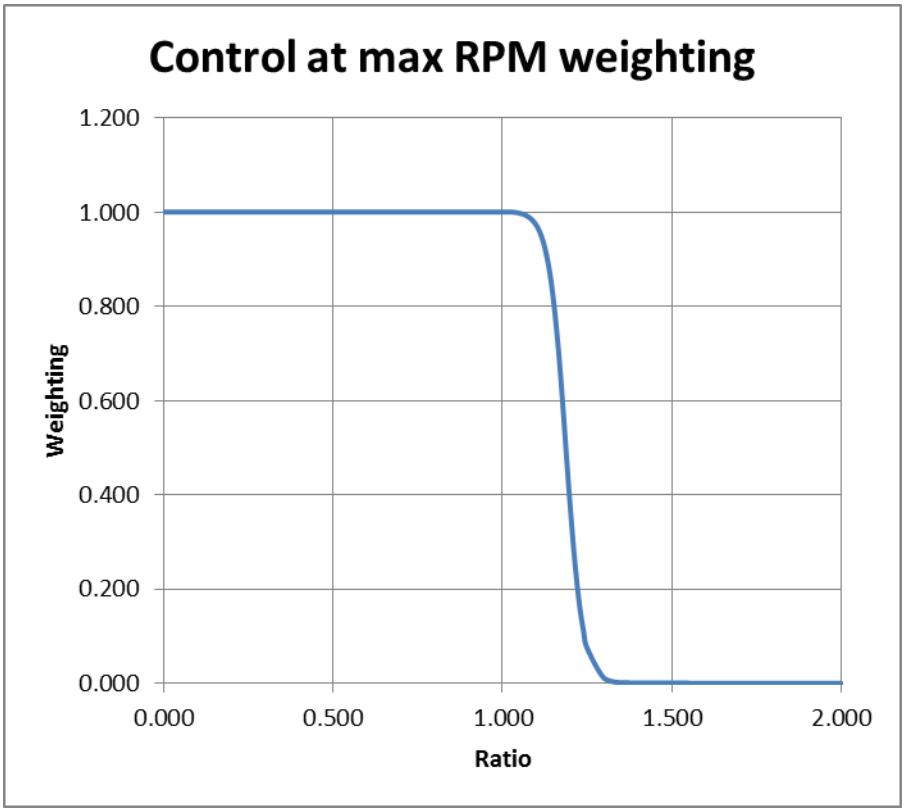

Figure B-2. Score weighting based on rpm ratio for control of rated rotor speed task

Cut-In Wind Speed Task

A team will earn 10 points for each half m/s bin below 5 m/s, inclusive of the lower bound and exclusive of the upper bound in which they can produce power, as defined in the cut-in wind speed task description (Section 7.2.4), up to the maximum score of 50 points for this task. The team receives one score based on its cut-in wind speed.

Durability Tasks

This portion of the turbine performance testing contest is scored on a pass/fail basis. If the turbine can produce power at both the beginning and end of the task, and not stop producing power for more than 10 continuous seconds at any time during the task, the team will receive 50 points. If the turbine experiences any faults or is not able to produce power for more than 10 continuous seconds during the 5-minute duration period, then the team will receive zero points. This includes faults that are visually observed during operation that do not cause a detected fault or a loss of ability to produce power such as high vibration, cracks, loss of parts or pieces of parts, or other problems.

Safety Tasks

This portion of the turbine performance testing is scored on a pass/fail basis in two parts. If the turbine achieves a successful shutdown, as described in the safety task description (see Section 7.2.6), upon manual initiation, the team will receive 25 points. If the turbine achieves a successful shutdown when disconnected from the load system, the team will receive an

additional 25 points. If the turbine does not spin fast enough to produce positive power during at least one wind speed of the power performance task, the score for the safety task will be zero.

Bonus Challenge

Teams will demonstrate their load system during the benchtop interview and during the operation of their turbine in the tunnel test. Note, the score below is independent from the overall score and will only be used to determine rankings within the bonus challenge.

Table B-7. Scoring Rubric for the Bonus Challenge

Description	Possible Points	Score
Bonus Challenge		
Effectively enables observers to perceive the productive value of the turbine and understand when it is consuming power and producing power at zero, low, medium and high levels.	10	
Provides an informative display of power production.	15	
Provides an informative display of energy production. (Must be capable of being reset, 0 points if not)	15	
Effectively demonstrates power being applied to a load of interest.	10	
Design is creative and original, not resembling prior art.	20	
The design is visually appealing, drawing and keeping the attention of viewers.	30	
	Total	

Appendix C. Communications and Business Operations

External Communications

The website will showcase the various elements of the competition, ongoing collegiate team engagement, and information about how to participate in future competitions. The website will also post important documents such as this manual and the Collegiate Wind Competition identity guidelines. The identity guidelines provide information about how the competition name, logo, and visual identity can be used.

Internal Communications

It is the team's responsibility to stay abreast of the latest competition communications from the organizers. Communication between the teams and the organizers occurs via one or more of the following:

- **Google Group**. Official communications suitable for viewing by all team members and organizers will be posted on the Google Group message board. Instructions on joining Google Group will be provided (by NREL) to the teams following the selection announcement.
- **Dropbox**. This tool is used by the organizers and teams to transfer large files, such as competition products. Notification of or requests for file transfers are made via the Google Group or email.
- **Conference calls**. Teams are strongly encouraged to participate in scheduled conference calls with the organizers. Invitations and instructions for participation in conference calls are provided by the competition coordinator via email until the Google Group has been established and then provided via the Google Group thereafter.
- **Meetings**. Before the event, the teams and organizers may have one or more in-person meetings. Notification of the date(s) and agenda(s) for these meetings will be made via the Google Group. Meetings will also be held on a daily basis throughout the event.
- **Email**. For expediency and to protect confidentiality, the organizers may choose to communicate with teams via team members' email addresses as listed in the Google Group database; however, most official communications occur via the Google Group message board. Teams can email the organizers at cwcrules@nrel.gov.

Branding

Team members agree to the use of their names, likenesses, content, graphics, and photos in any communication materials issued by the organizers and event sponsors.

Content and images (graphics and photos), and any publications in which the content and images appear, may be viewable and made available to the general public via the websites of the U.S. Department of Energy, National Renewable Energy Laboratory, and event sponsors with unrestricted use.

The organizers and event sponsors will make all reasonable efforts to credit the sources of content and images, although they may be published without credit. To ensure proper usage of and credit for images, teams should submit photos and graphics by uploading them to the dropbox.

Teams are encouraged to develop branding for their turbines and teams. This branding, including web pages, Facebook or other social media, outreach material, and team T-shirts are welcome during the competition. The use of the Competition logo or name as part of individual school/team branding is covered by the identity guidelines provided.

Confidentiality and Intellectual Property

There are portions of the competition that are decidedly open to the public for purposes of generating interest and providing general information. In addition, team members should keep in mind that various media outlets will be present during the competition. Any information made known and/or discussed should be expected to receive widespread and uncontrolled dissemination. Teams should consider (in advance) what level of information regarding all aspects of their turbine, business plan, and so on they desire to have publically available, versus information that provides a competitive advantage, is critical to their performance in the competition, or is of a "proprietary" nature and essential to potential future business endeavors.

Judging and Scoring

Panels of judges are responsible for scoring team performance in each contest (i.e., business plan, technical design, deployment strategy, and turbine testing). The judges will have detailed expertise related to the content they are responsible for evaluating. Each panel will also include diverse backgrounds that allow the judges to evaluate performance from a variety of angles.

Competition organizers ensure that judges will not:

- Have personal or financial interests in, or be an employee, officer, director, or agent of any entity that is a registered participant in the competition
- Have a familial or financial relationship with an individual who is a registered participant
- Provide advice to teams, although they can provide clarification on the judging process
- Discuss team performance with other teams or their advisors.

Names of the selected judges will be announced just prior to the Competition.

Judging Rubrics

Judges will use detailed scoring rubrics to evaluate team performance in each of the categories. These rubrics give all participants a clear idea of what they will be evaluated on in each contest.

Each judge will fill out a rubric independently as the team is performing. At the completion of each event segment, judges will discuss each team's performances before finalizing the rubrics. The team of judges will submit one unified rubric to the head rules official for official scoring purposes. Products submitted prior to the event will be thoroughly reviewed and evaluated by the judges.

Team Feedback

In an effort to provide as much feedback as possible, teams will receive copies of the scored rubrics, which will be provided following completion of the entire competition. Teams will also receive a short narrative that is derived from the judges' deliberation after their presentations and any notes judges may have written on the individual rubric forms.

Appendix D. Product Submission Instructions

Products are on time if they are received by the competition manager by the respective due date listed in the section that describes that product. Late penalties are listed in Appendix B.

All products must be saved in the formats indicated (see each product section) and submitted to organizers packaged as a single .zip file.

Submission Locations

Products must be delivered to the competition dropbox or at cwcrules@nrel.gov.

PDF Requirements

PDFs must meet the following criteria:

- Embedded fonts
- A minimum resolution of 300 dpi.

If a software application does not support a direct-to-PDF function, create a postscript file by printing to a postscript printer with the "print to file" option selected. Use this postscript (.ps or .prn) file to create a PDF using Acrobat Distiller's high-resolution job settings. Points to remember include:

- Creating a PDF from scans, or by outputting the content into a raster image format (e.g., .jpg, .tiff, .png, or .gif) and then creating a PDF from the images is not acceptable
- All-raster PDFs are large files at 300 dpi but are of unacceptable quality at lower resolutions, and are not scalable without degradation.

Audio Visual Presentation Requirements

Optional audio visual presentation format requirements include the following:

- A .MOV or H.264 compressed.MP4 (MPEG-4) file type
- Maximum runtime of 3–3.5 minutes
- A 16:9 aspect ratio
- A resolution of 720 x 480
- A verbatim transcript of the audio narrative to meet Section 508 accessibility standards. The transcript should be submitted in a Microsoft Word-compatible format. For an example of a text version script, see the Wind Power Animation (Text Version).

Content requirements include the following:

- Video footage of the actual wind turbine
- Still photos and graphics (optional)
- A realistic preview of what is experienced during evaluation at the competition

- An explanation of how the project meets the criteria listed in the relevant contest section of the rules
- An audio narrative that explains what viewers are seeing and describes the underlying philosophy
- Only originally created or properly credited work that does not violate U.S. copyright laws may be used
- No background music that violates U.S. copyright laws; all incorporated music must be an original or royalty-free composition and proof of licensing must be submitted with the final file and transcript
- Interactive elements must be accessible to those with visual disabilities.

Electronic File-Naming Instructions

The required file-naming convention for all electronic files is:

[TEAM ABBREVIATION]_[PRODUCT ABBREVIATION]_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]

See Table D-1 for a list of team names and abbreviations and Table D-2 for product names and abbreviations.

Example: An audio visual presentation submitted by the University of Alaska Fairbanks on May 1, 2016, would have the following file name: UAF_AV_2016-05-01.MOV.

Table D-1. Team Names and Abbreviations

Team Name	TEAM ABBREVIATION
Boise State University	BSU
California Maritime Academy	CAL_MARITIME
California State University, Chico	CHICO_STATE
Kansas State University	KSU
Northern Arizona University	NAU
Pennsylvania State University	PSU
Universidad del Turabo	UT
University of Alaska Fairbanks	UAF
University of Maryland	UMD
University of Massachusetts Amherst	UMA
University of Massachusetts Lowell	UML
University of Wisconsin-Madison	UWM

Table D-2. Product Names and Abbreviations

Product Name	PRODUCT ABBREVIATION
Written report	REPORT
Public pitch presentation or poster	PITCH
Audio visual presentation	AV
Product zip before competition	PORTFOLIO